

National Park Service
U.S. Department of the Interior
Natural Resource Stewardship and Science



Predictive Noise Modeling in Parks

Natural Sounds & Night Skies Division

EXPERIENCE YOUR AMERICA™



Works to protect, maintain, or restore acoustical environment and night sky quality throughout the National Park System. Works in partnership with parks and others to increase scientific understanding and inspire public appreciation of the value and character of soundscapes and night skies.

-Natural Sounds and Night Skies Mission

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NPS Policies on Noise Modeling

- Superintendents will identify what levels of sound constitute acceptable impacts —MP 4.9
- The Service will prevent inappropriate or excessive sounds (noise) —MP 5.3.1.7
- The Service will support studies to
 - provide a sound basis for policy, planning, and decision-making;
 - develop effective strategies, methods, and technologies **to predict**, avoid, or minimize unacceptable impacts... —MP 8.11.2, also 4.2.1
- The Service will strive for natural quiet (*i.e. no noise audibility*) —MP 8.2.3

What Policies or Decision-Making?

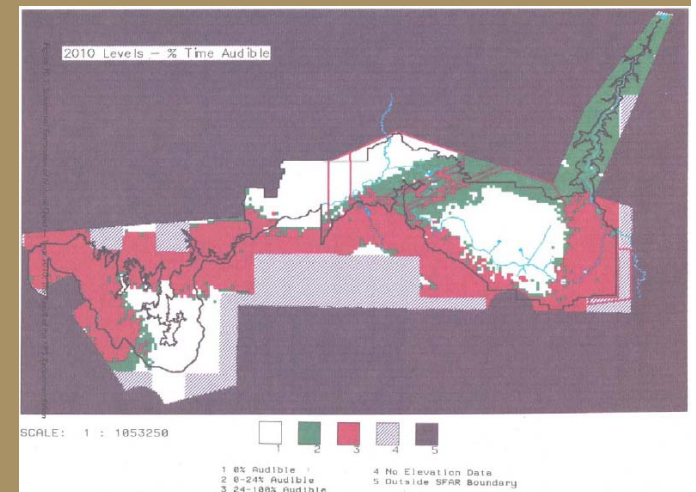
- How park use may affect natural quiet?
 - Type of snowmobile, number, and timing
 - Type of boat motor, horsepower, or number
 - Areas in which ORV use may be permitted
- How to mitigate noise sources?
 - Locations where terrain shielding may reduce impacts
 - Optimal locations for buildings, earth berms, or walls
 - Times when sound propagation is greatest and certain activities should be avoided
 - Sensitive areas where noise should be avoided
 - Technologies that may reduce noise impacts

How Models Aid Decision-Making

- Visual tools to educate and inform both park managers and stakeholders
 - Noise source footprint
 - Terrain shielding, other effects
 - Noise metrics
- Analytical tools to assess levels of noise exposure
 - Describe current conditions
 - Predict future conditions
 - Compare and contrast management alternatives

History of NPS Noise Modeling

- National Parks Overflight Act of 1987 required substantial restoration of natural quiet in GRCA
- NPS defined 'natural quiet' as no aircraft audible in 50% or more of the park for 75-100% of the day
- How can we possibly know this?
 - Only via computer modeling !
- NPS sponsors NODSS



History of NPS Noise Modeling

- FAA and NPS assemble team to test computer models
- NPS chooses **NMSim** as model of choice
- NPS publishes Federal Register Notice
- Meanwhile, improvement continues...

Aircraft Noise Model Validation Study

HMMH Report No. 295860.29

January 2003

Prepared for:

National Parks Service
Denver Service Center

FICAN

Federal Interagency Committee on Aviation Noise

Assessment of Tools for Modeling Aircraft Noise in the National Parks

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March 18, 2005



U.S. Department of the Interior
National Park Service
Denver Service Center
Environmental Management and Planning Division
Aviation Policy

wyle

Wyle Laboratories

- In 2004, FAA and DOI form joint technical working group on modeling
- FICAN designates **INM** 6.2 as best practice model for ATMP parks

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Where are we now?

- Recent steps by NSNSD
 - Identified need to assist parks
 - Acquires training
 - Recognized need to upgrade **NMSim**
 - Developed new iterative tool for alternatives
- Accomplishments – today
 - Noise models calculated for various parks
 - Grand Canyon Tour Aircraft
 - Yellowstone Winter Use
 - BITH Oil and Gas
 - MORR Wash Hdqrts Unit Traffic
 - GLAC Motorcycle Noise

Computer Noise Models—Today

- Aircraft Noise Models
 - FAA Integrated Noise Model (INM → AEDT)
 - NOISEMAP Simulation Model (NMSim)
 - NPS Overflight Decision Support System (NODSS)
- Traffic Noise Models
 - FHWA Traffic Noise Model (TNM)
 - Datakustik CadnaA (implementation of TNM)
 - NOISEMAP Simulation Model (NMSim)
- Other Noise Models
 - Datakustik CadnaA, SoundPLAN, ENM, Nord2000
 - Historic: Army ADRPM, SPreAD (based on ADRPM)
 - Construction: FHWA RCNM

How do we measure sound?

We measure in A-weighted decibels (dBA)

Park Sound Sources

Military jet at 100 m AGL (YUCH)

Thunder (ARCH)

Snowcoach at 30 m (YELL)

Conversation at 5 m (WHMI)

Crickets at 5 m (ZION)

Leaves rustling (CANY)

Volcano crater (HALE)

Common Sound Sources

Train horn at 1 m

Jackhammer at 2 m

Curbside of busy street

Busy restaurant

Residential area at night

Whispering

Human breathing at 3 m

dBA

120

100

80

60

40

20

10

Sound Propagation

What exactly are we modeling?

- Noise Sources and How they Radiate Sound
- Sources of Attenuation for Noise Sources
 - Atmospheric Absorption
 - Ground Effect
 - Terrain Shielding and Barrier Effects (Screening)
 - Foliage
- Effects of Buildings, Walls, Windows, Ducts, Stacks
- Other Sources of Variability
 - Atmospheric Conditions (Stability)
 - Refraction (Temperature Profile)*
 - Wind (Wind Profile)*

*these can also increase sound

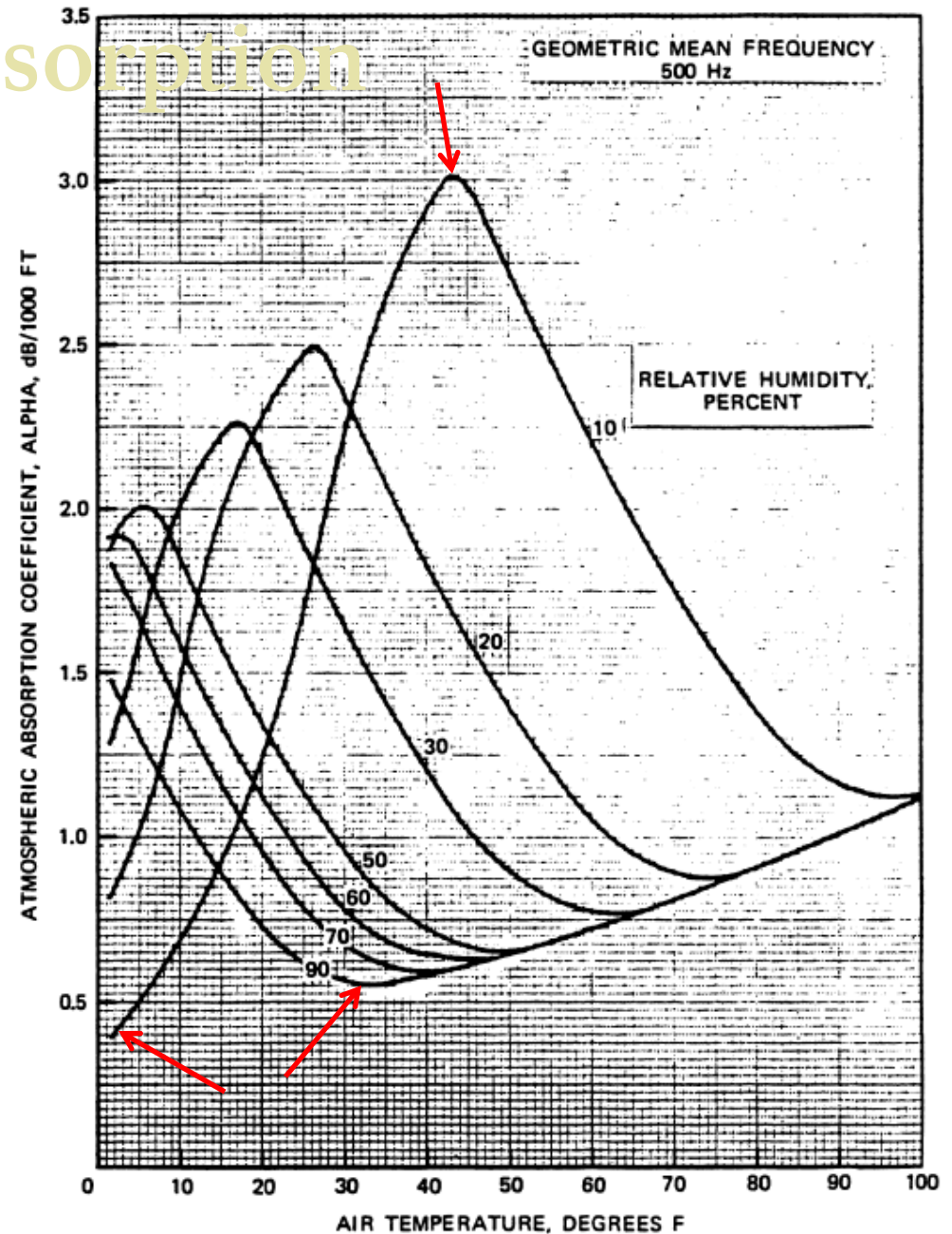
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Sound Propagation—Applicable Standards

- ISO 9613-1 and 9613-2
 - Atmospheric Absorption, Ground Effect, Screening, Barriers, Reflections, Foliage, etc.
 - Used by **TNM**, **CadnaA**, **SoundPLAN**
- ANSI S1.26
 - Atmospheric Absorption, used by **NMSim**, **SPreAD-GIS**
- SAE ARP 866A
 - Atmospheric Absorption, used by **INM**
- CONCAWE [Manning, 1981]
 - Atmospheric Absorption, Ground Effect, Stability
 - Used by **ENM**, **CadnaA** (Stability, including wind)

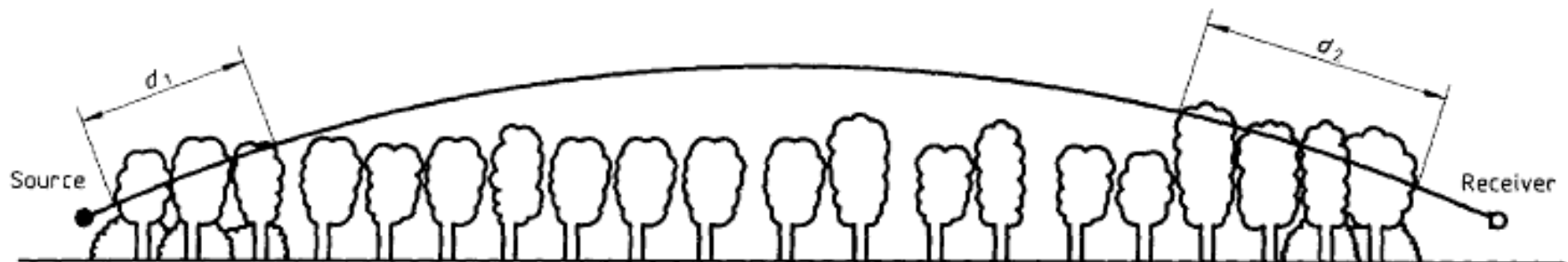
Atmospheric Absorption

- Air absorbs sound with distance
- Amount of absorption depends on temperature, humidity, and frequency
- Generally increases with frequency
- Absorption can vary by a factor of 10 or more!



Attenuation by Foliage (Scattering)

- Scattering effect of many leaves, branches, etc.
- Small for small areas or rows of trees, like 10-20 m
- For larger extents, increases dramatically
- No additional attenuation for large distances !



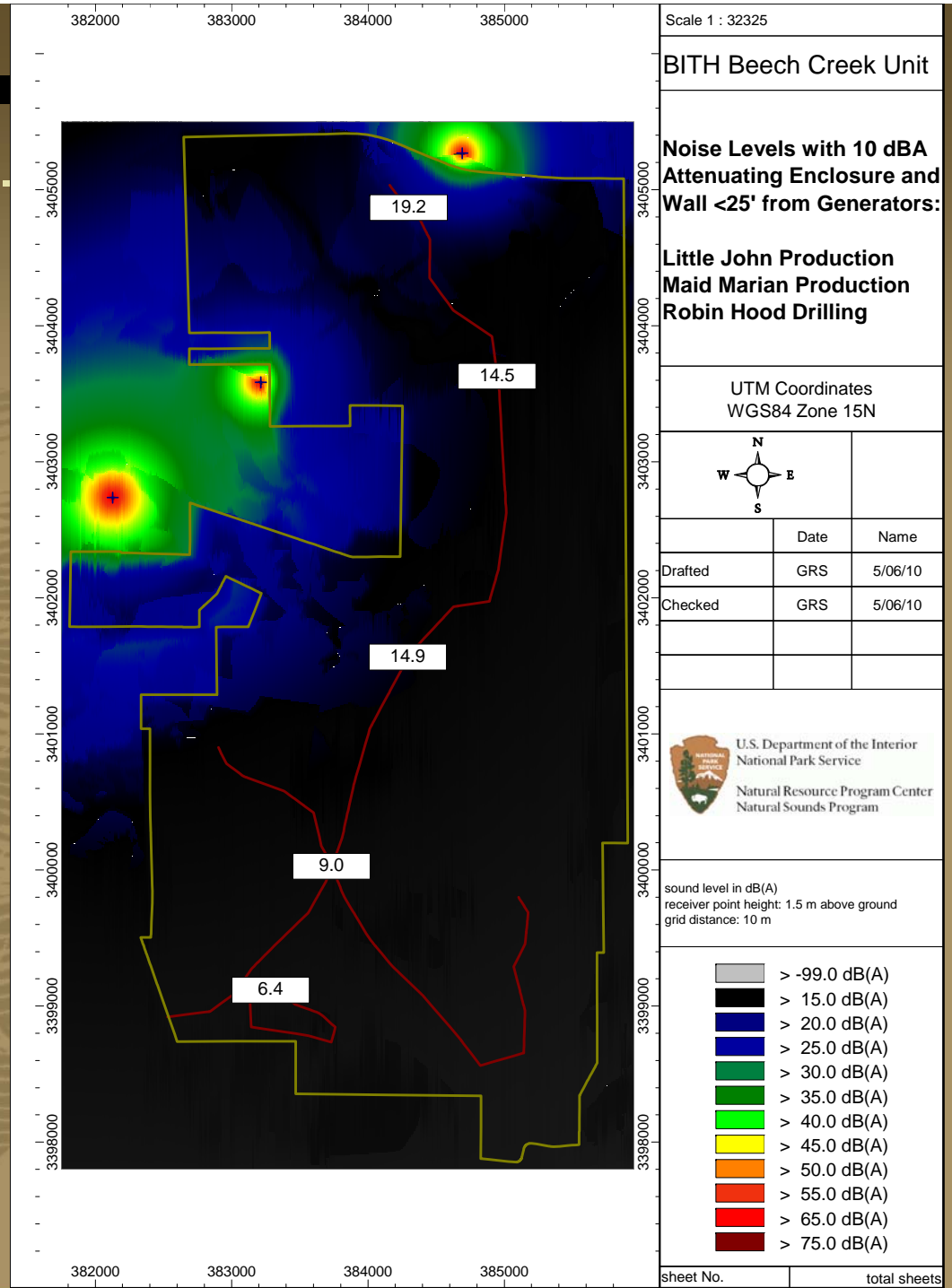
NOTE — $d_t = d_1 + d_2$

For calculating d_1 and d_2 , the curved path radius may be assumed to be 5 km.

Figure A.1 — Attenuation due to propagation through foliage increases linearly with propagation distance d_t through the foliage

NPS Modeling

- Predicted park noise levels
- Potential scenario
- Noise barrier and genset enclosure mitigation
- Shows effect of foliage in park



NPS Win—Oil & Gas Noise Reduction

- Noise barrier
- Productive use of emergency pit
- Noise reduction of 5-10 dB expected



Ground Effect

- Ground effect is due to interference of reflected wave
- Ground absorption varies widely
- Varies with frequency
- Consider snow to rock

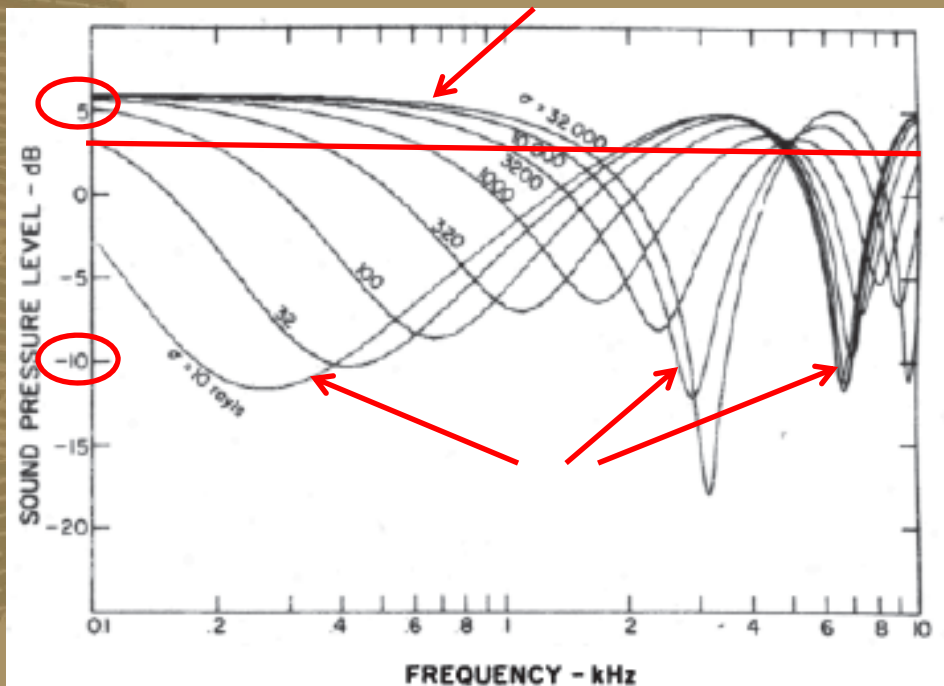
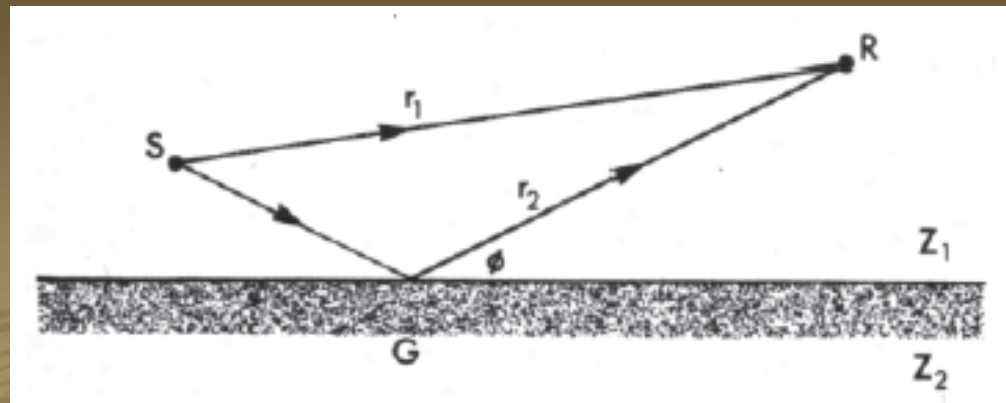
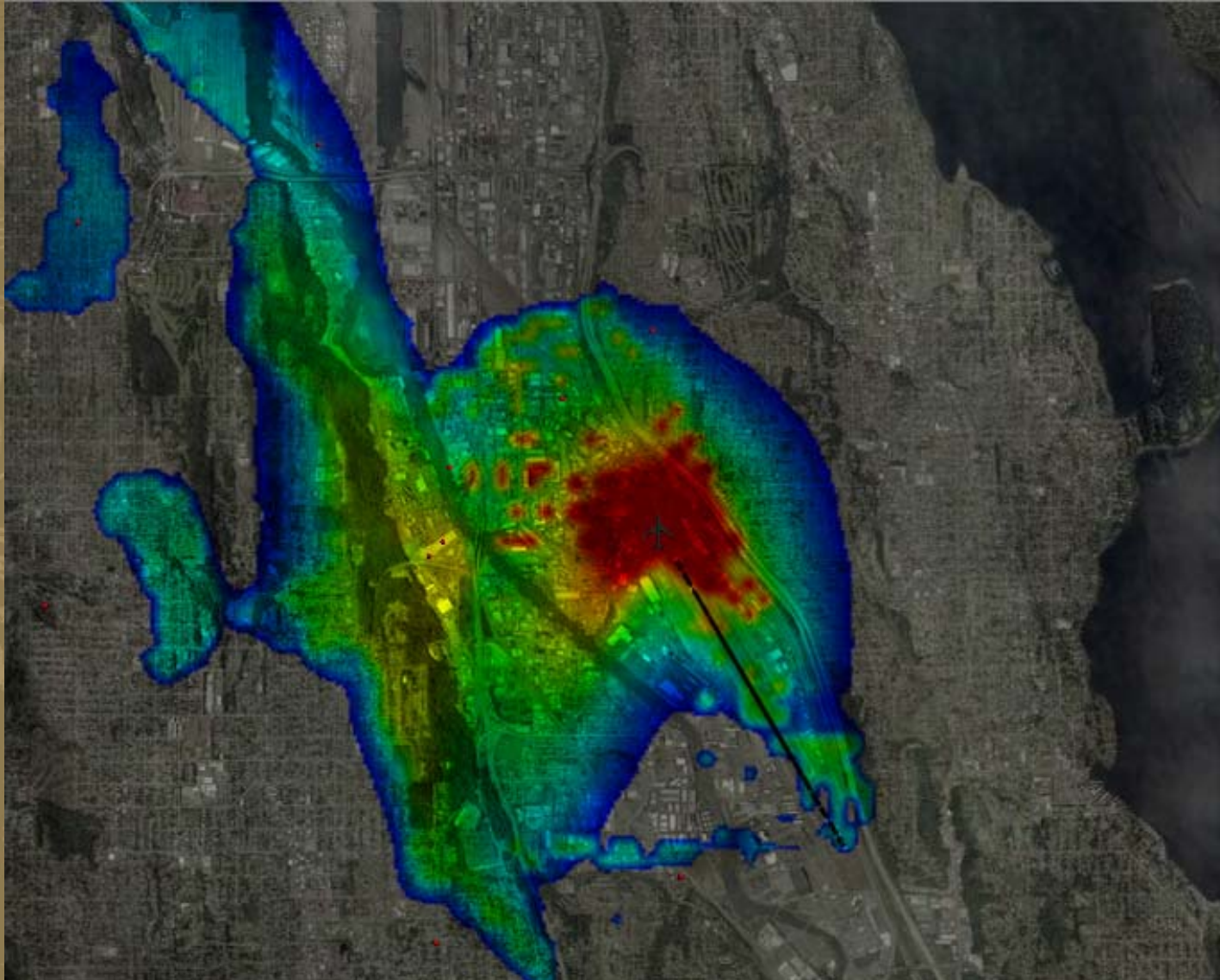


FIG. 2. Set of predicted spectra for various values of flow resistivity of the ground surface. Reference sound pressure level is that which would exist at the receiver in free space. Source and receiver heights 0.31 and 1.22 m, respectively, and horizontal separation 15.2 m.

Terrain Shielding (Screening)



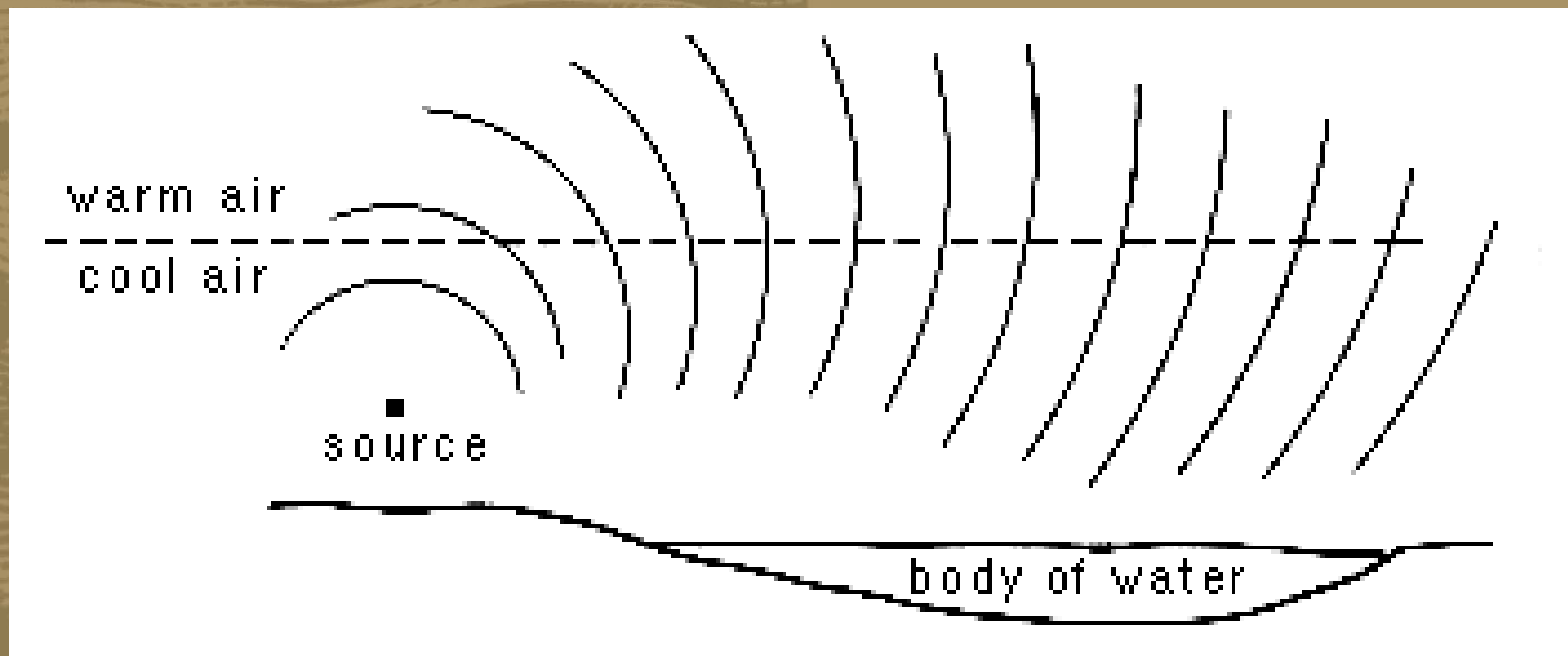
Flat terrain



Atmospheric Conditions – Refraction

- Strong effect caused by changes in wave speed
- Wave speed increases with temperature and downwind
- Temperature inversions after sunset or over a large body of water can cause distance sounds to become louder

wind → → →



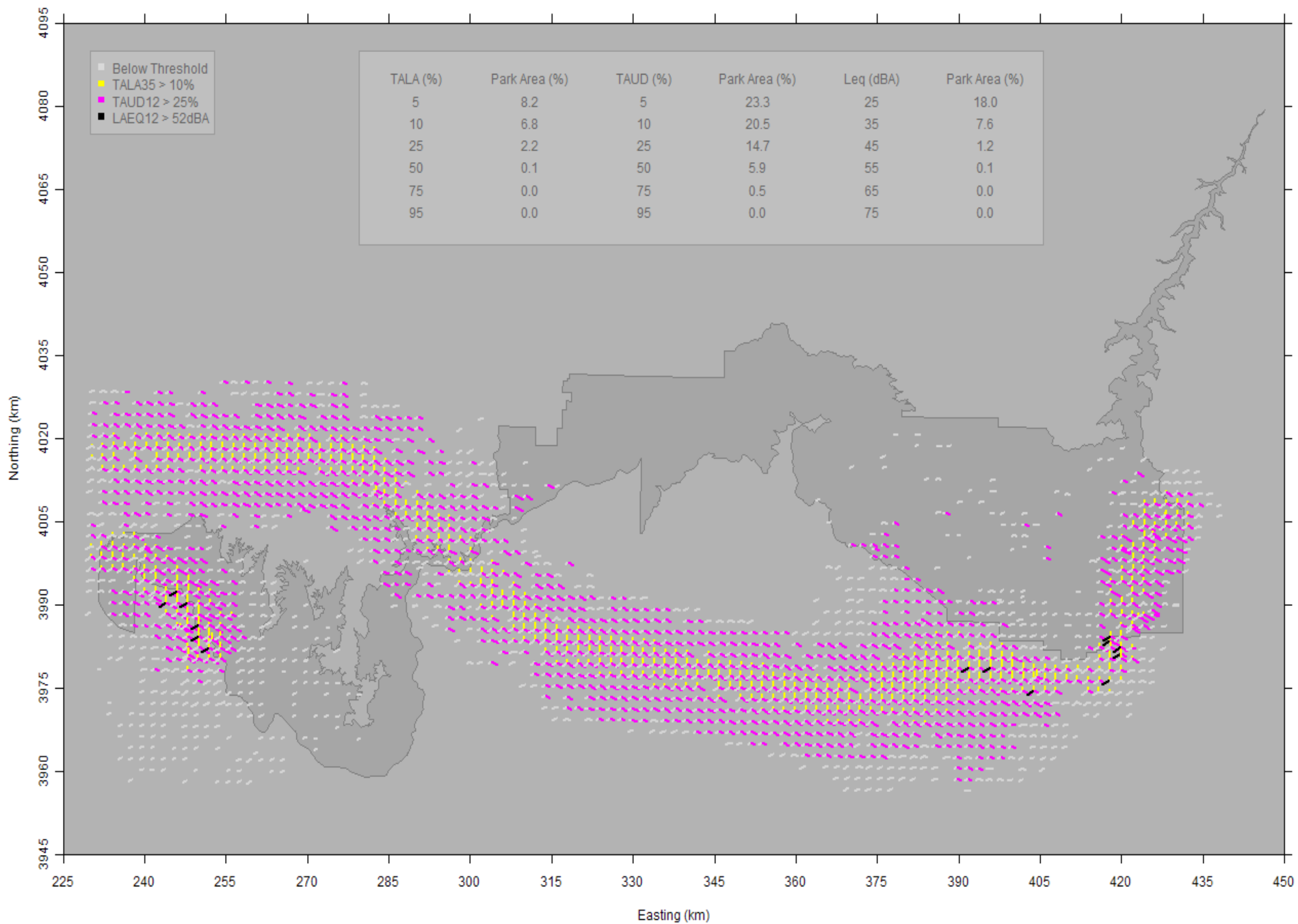
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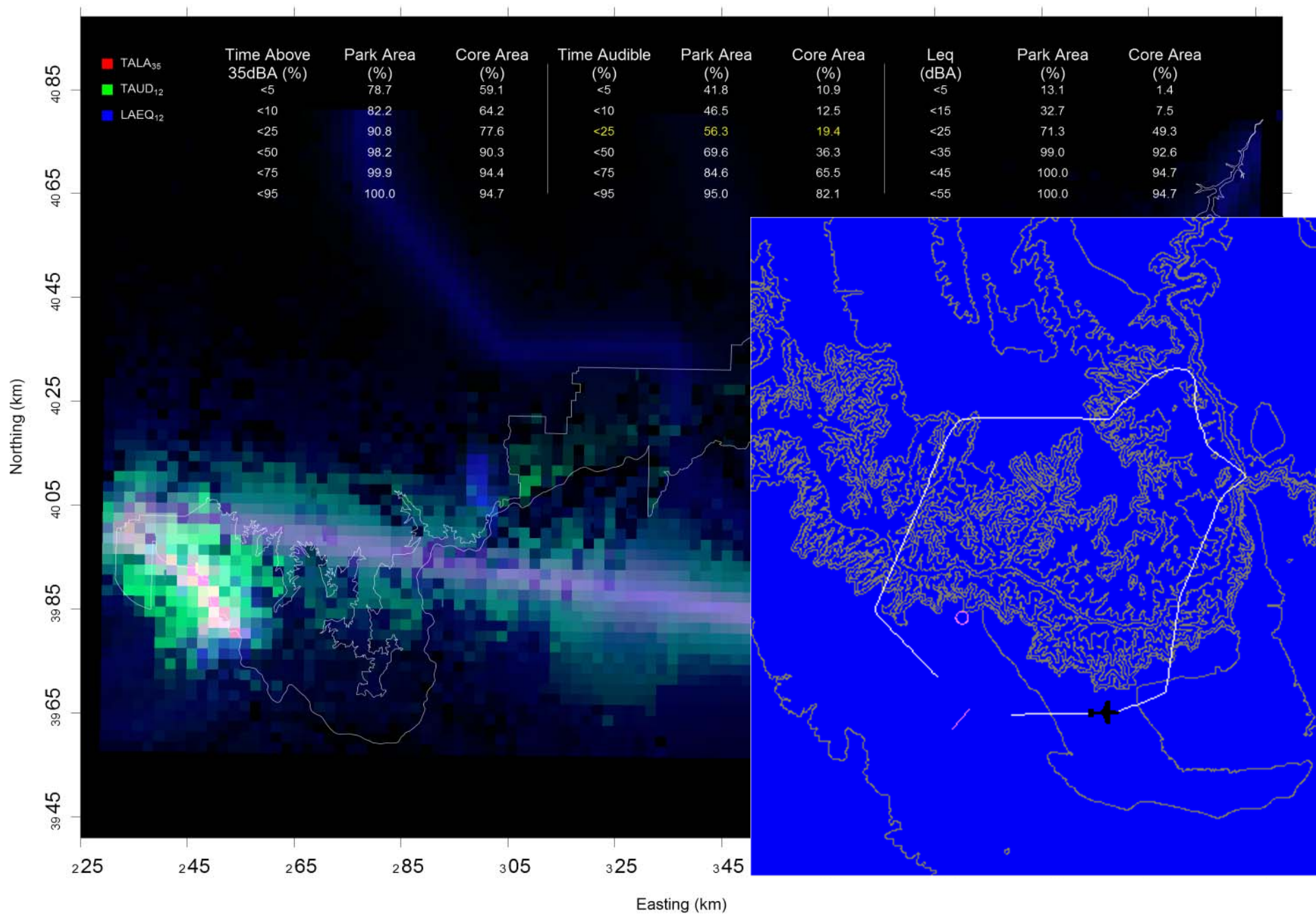
Sound Propagation Summary

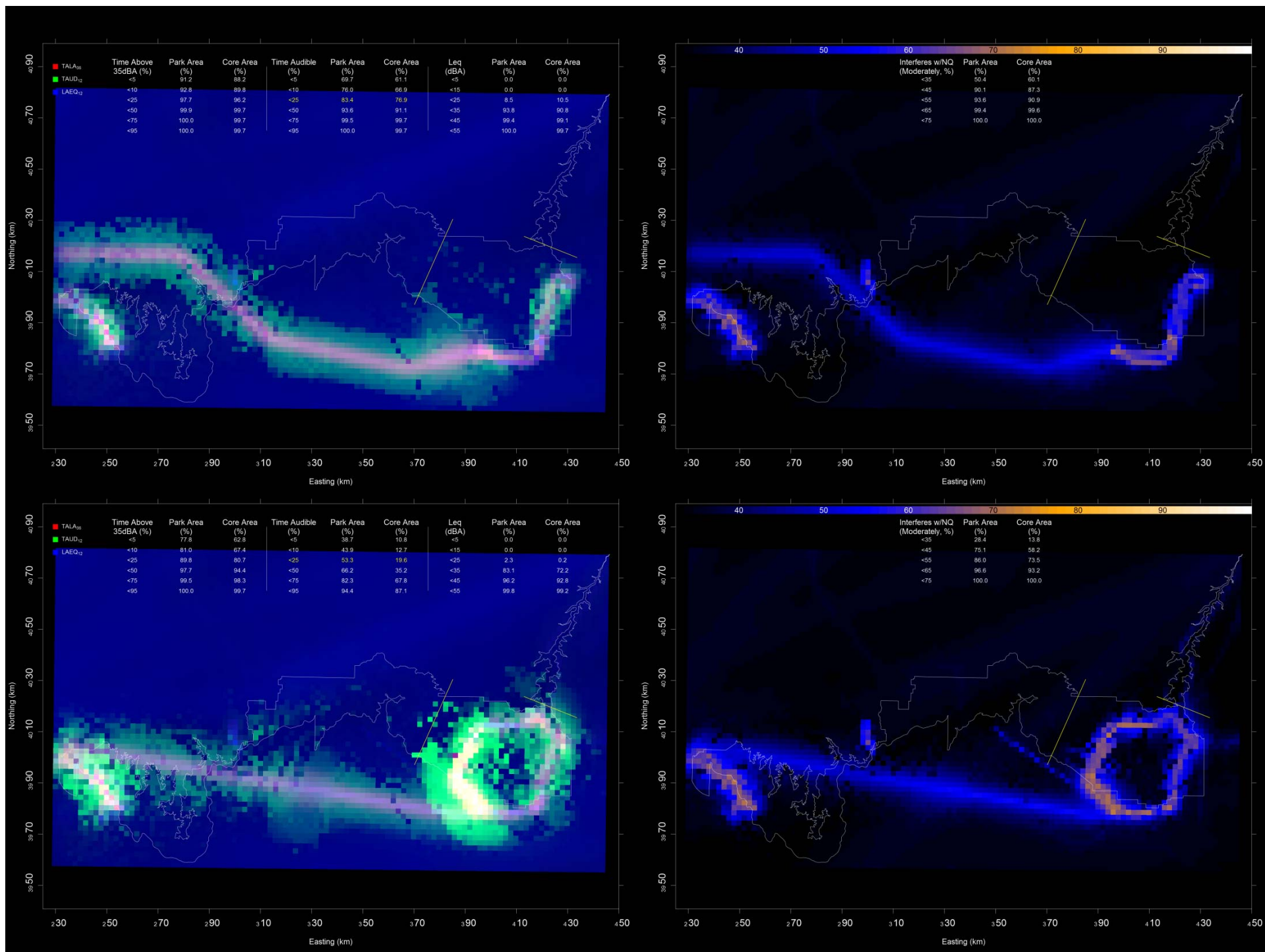
- What does this mean for large parks?
 - Noise model complexity increases with terrain features
 - Need to consider all site specific conditions
 - Use full spectrum source data if available
 - Document model assumptions
 - Atmospheric instability?
 - Very windy sites?

Computer Noise Models—Advantages

- Largest aircraft source database: INM, AEDT
- New advanced hybrid algorithm: AEDT
- Most NPS metrics, nice animations: NMSim
- Uses curved ray approach: Nord2000
- Multiple traffic source heights: TNM, CadnaA
- Approved for Federal-aid projects: TNM
- Best GIS import and most overall capabilities: CadnaA



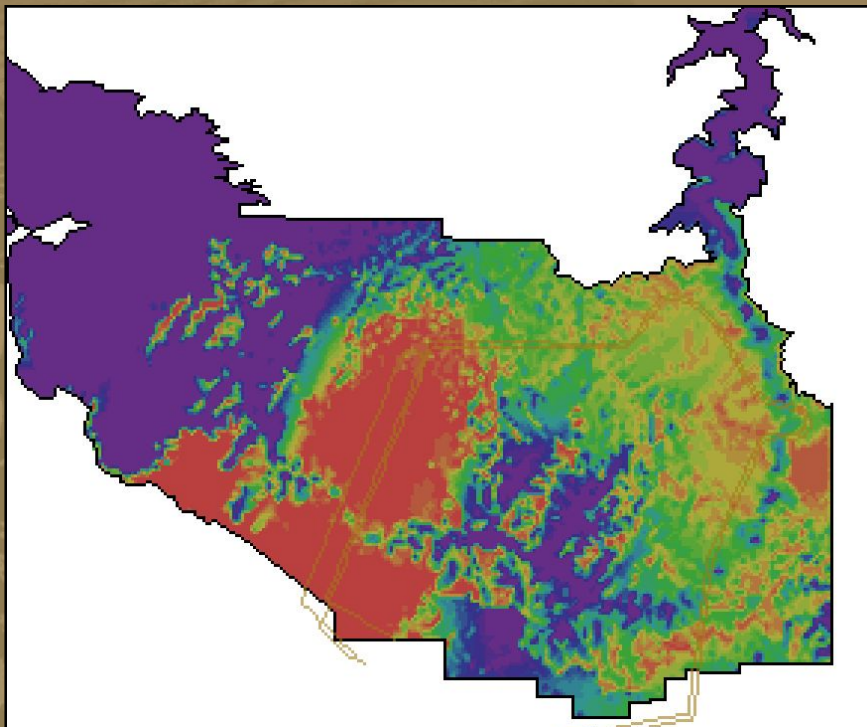




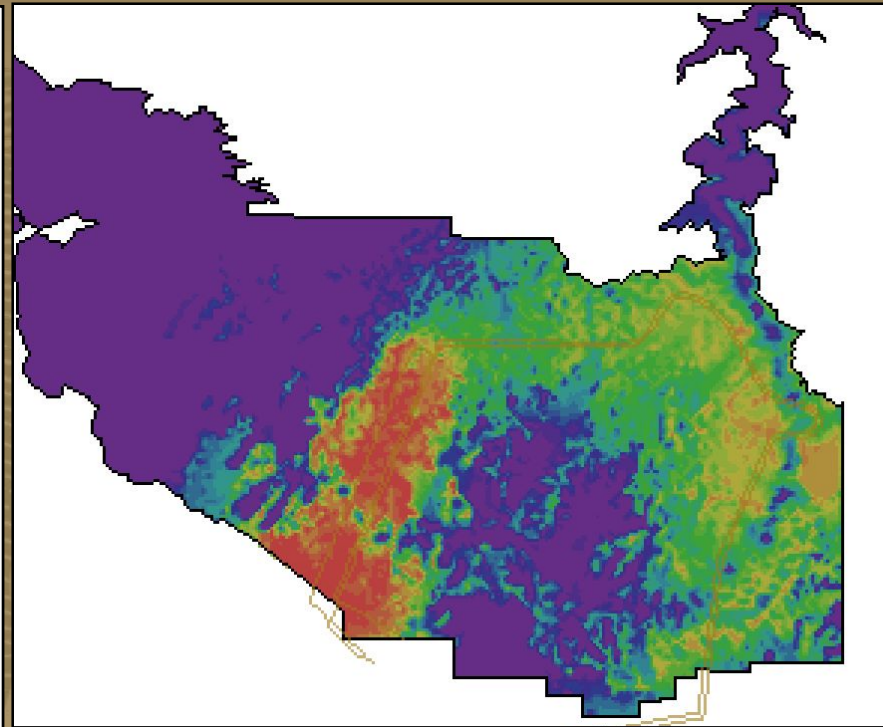
Dragon and Zuni Corridors

Current Fleet Mix

All Quiet Technology



31.7% of the park (61.2% of east end)



24.3% of the park (47.0% of east end)
(Change = -138.8 sq-mile, -7.4% of the park, -14.2% east end)

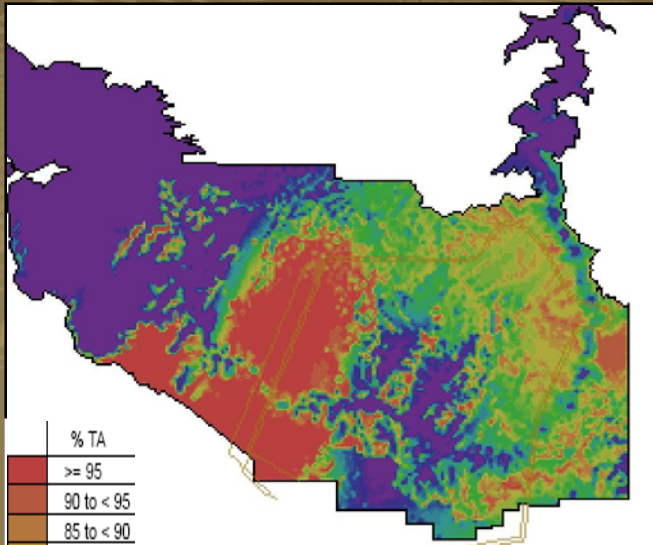
| % TA |
|------------|
| >= 95 |
| 90 to < 95 |
| 85 to < 90 |
| 80 to < 85 |
| 75 to < 80 |
| 70 to < 75 |
| 65 to < 70 |
| 60 to < 65 |
| 55 to < 60 |
| 50 to < 55 |
| 45 to < 50 |
| 40 to < 45 |
| 35 to < 40 |
| 30 to < 35 |
| 25 to < 30 |
| 20 to < 25 |
| 15 to < 20 |
| 10 to < 15 |
| 5 to < 10 |
| 0 to < 5 |

Baseline

Existing Dragon Corridor

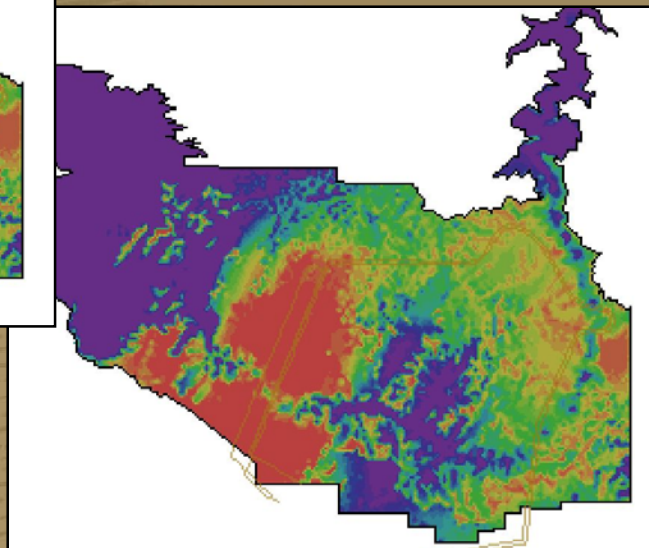
Dragon -1000'

Dragon -1000', QT

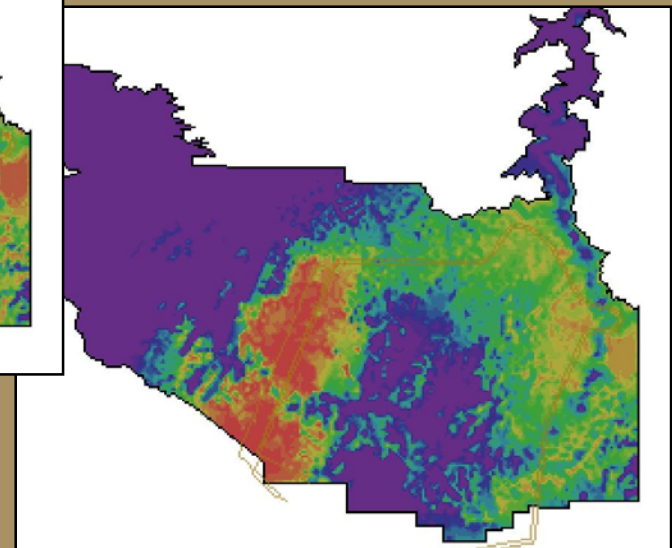


| % TA |
|------------|
| ≥ 95 |
| 90 to < 95 |
| 85 to < 90 |
| 80 to < 85 |
| 75 to < 80 |
| 70 to < 75 |
| 65 to < 70 |
| 60 to < 65 |
| 55 to < 60 |
| 50 to < 55 |
| 45 to < 50 |
| 40 to < 45 |
| 35 to < 40 |
| 30 to < 35 |
| 25 to < 30 |
| 20 to < 25 |
| 15 to < 20 |
| 10 to < 15 |
| 5 to < 10 |
| 0 to < 5 |

31.7% of the park
(61.2% of east end)

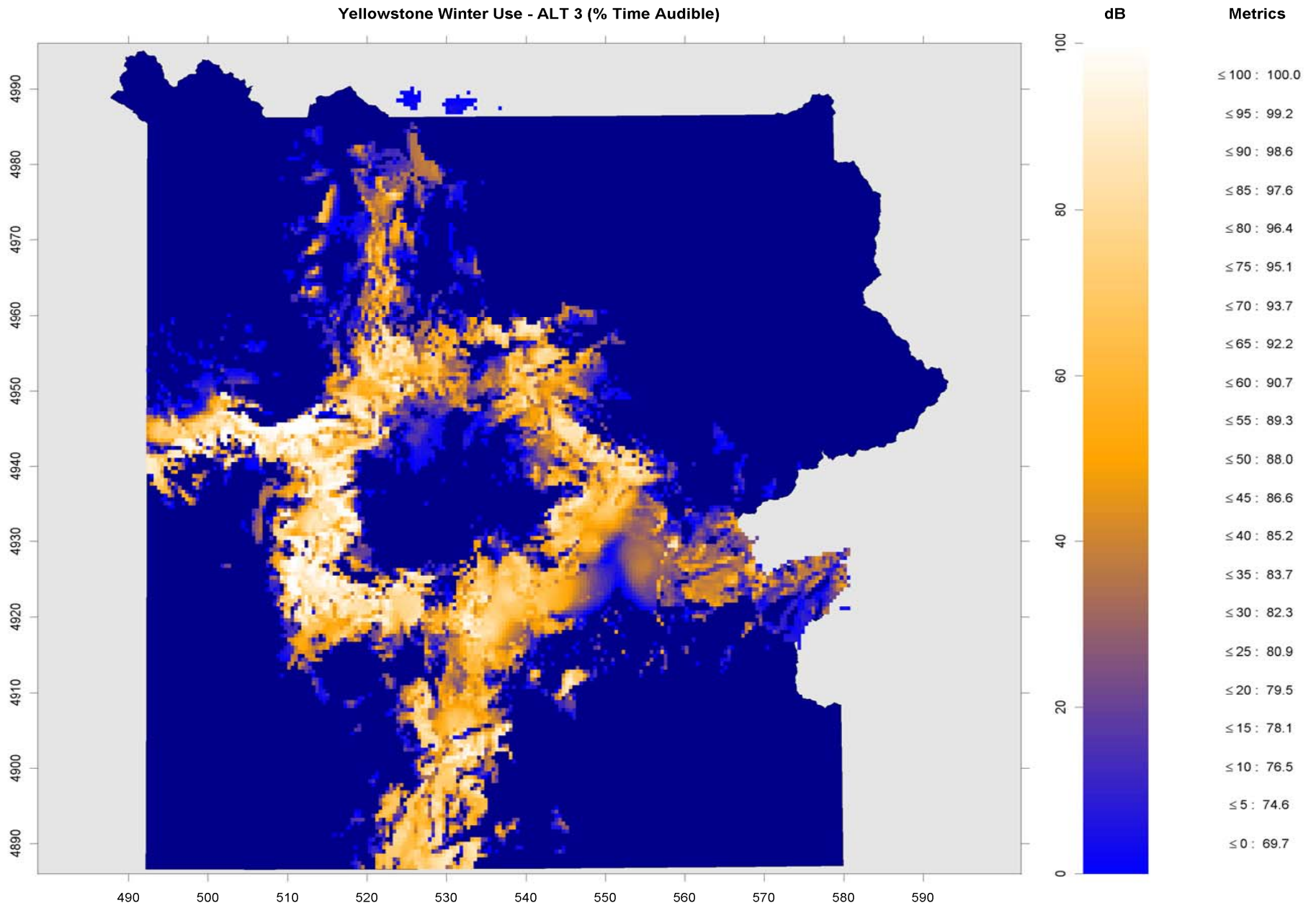


31.2% of the park (60.3% of east end)
(Change = -8.3 sq-mile, -0.4% of the park, -0.8% of east end)



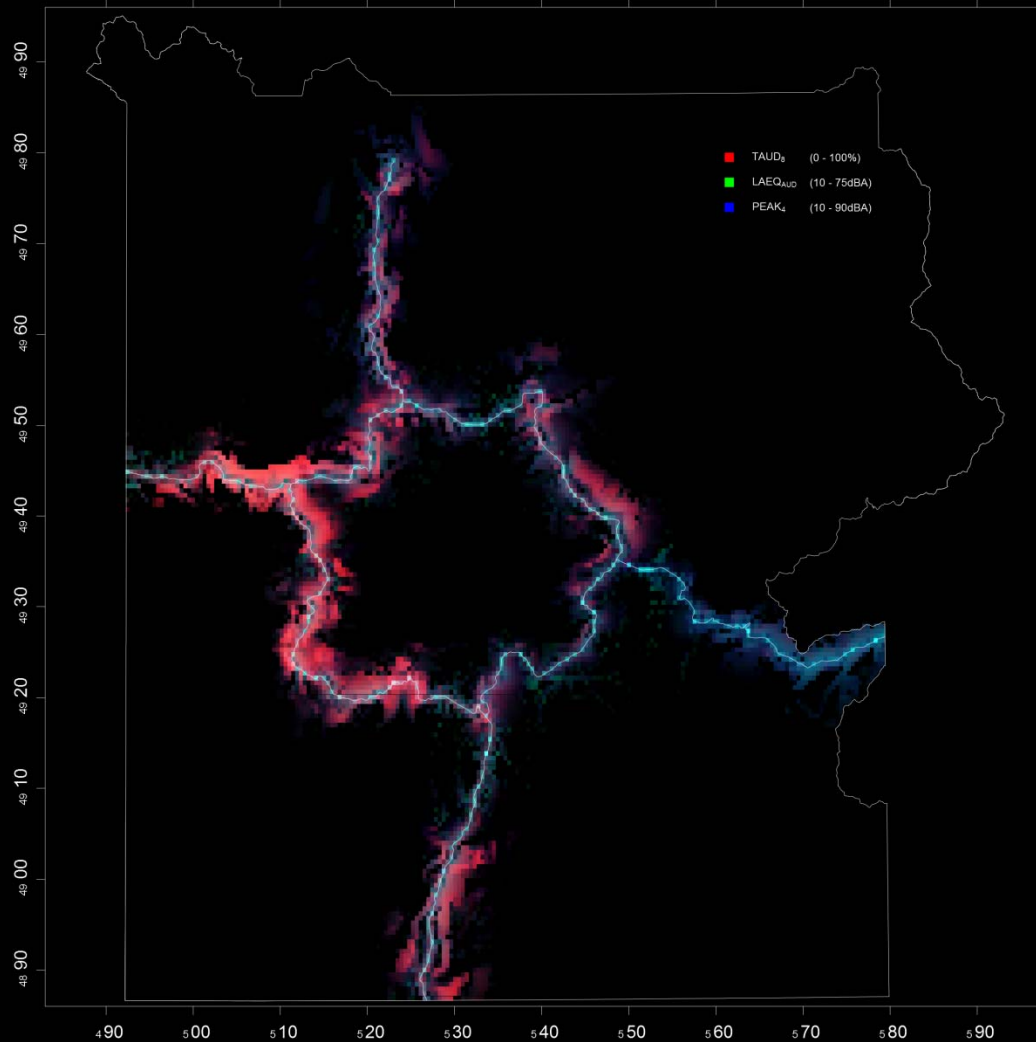
24.2% of the park (46.7% of east end)
(Change = -141.7 sq-mile, -7.5% of the park, -14.5% of east end)

Yellowstone Winter Use - ALT 3 (% Time Audible)

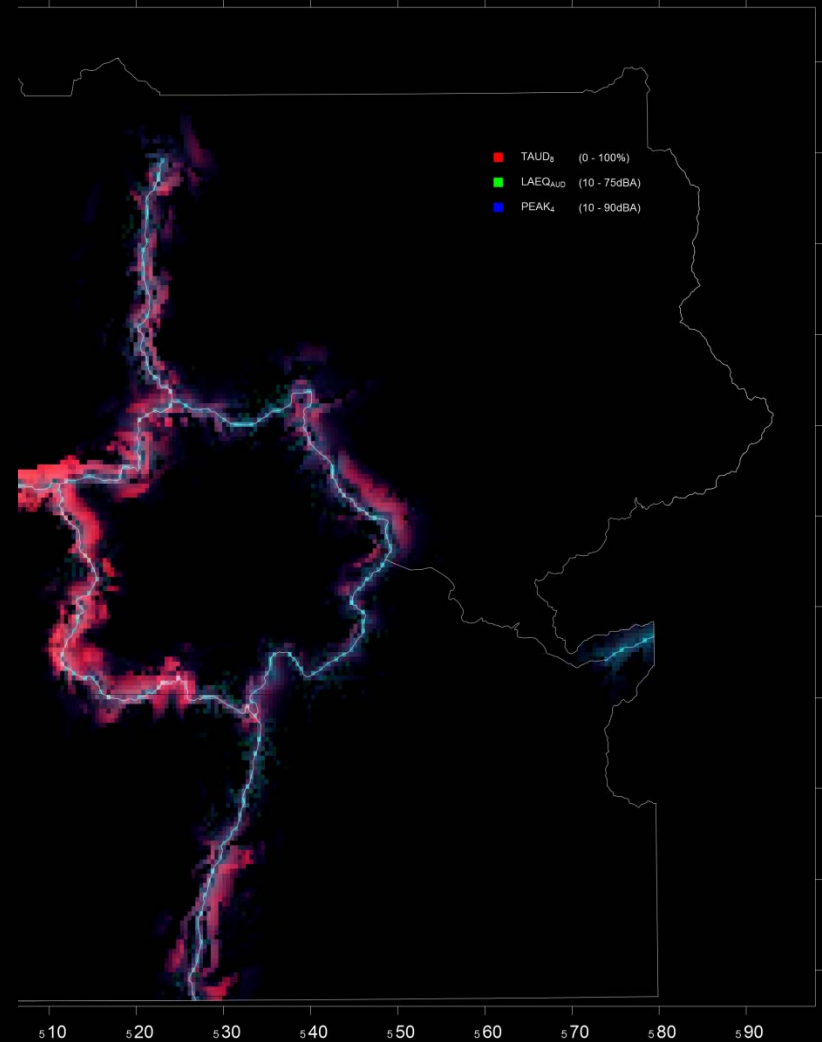


Explicit spatial contrasts of alternatives

Yellowstone Winter Use - aIU (All Metrics)

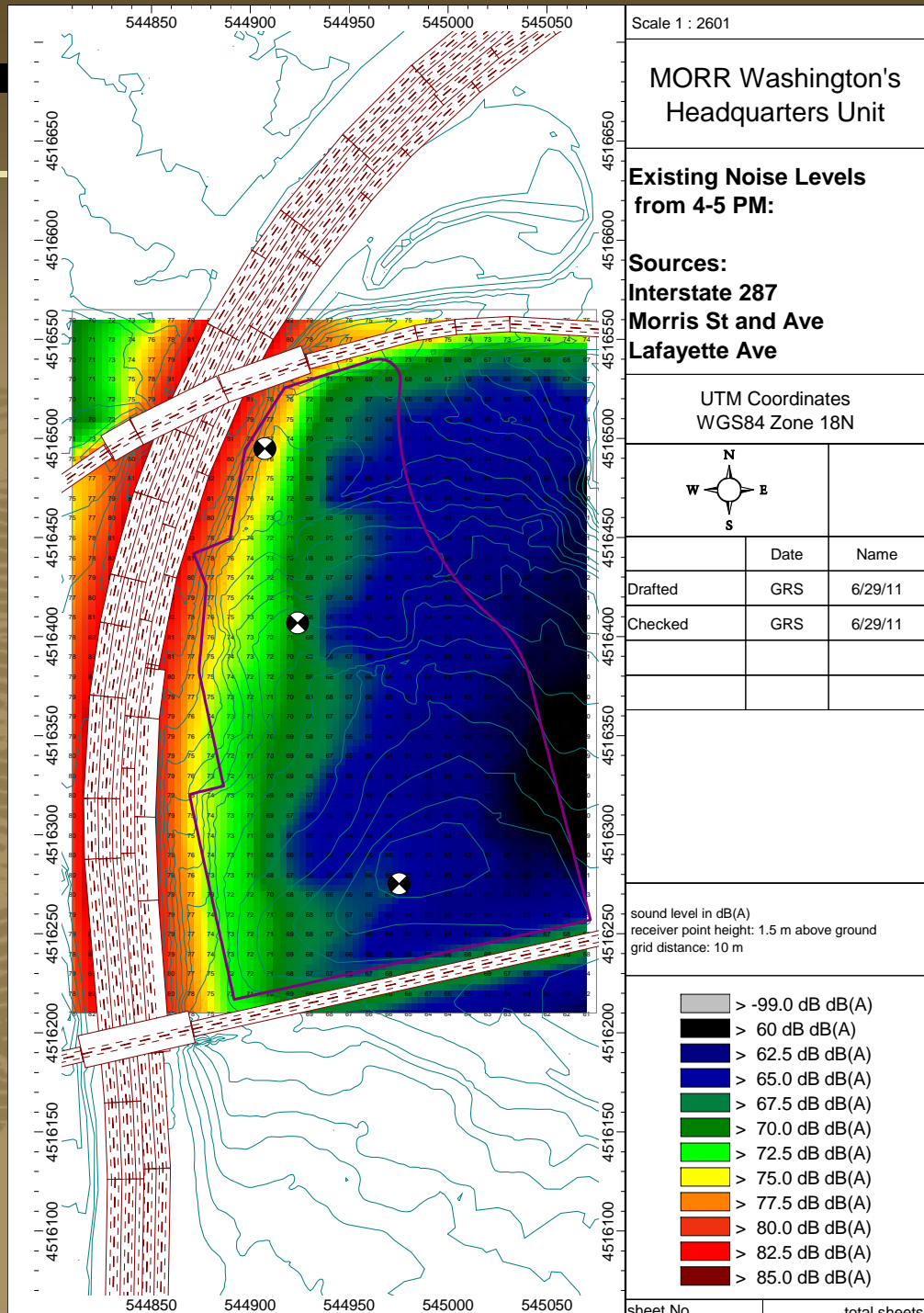


Yellowstone Winter Use - a3 (All Metrics)



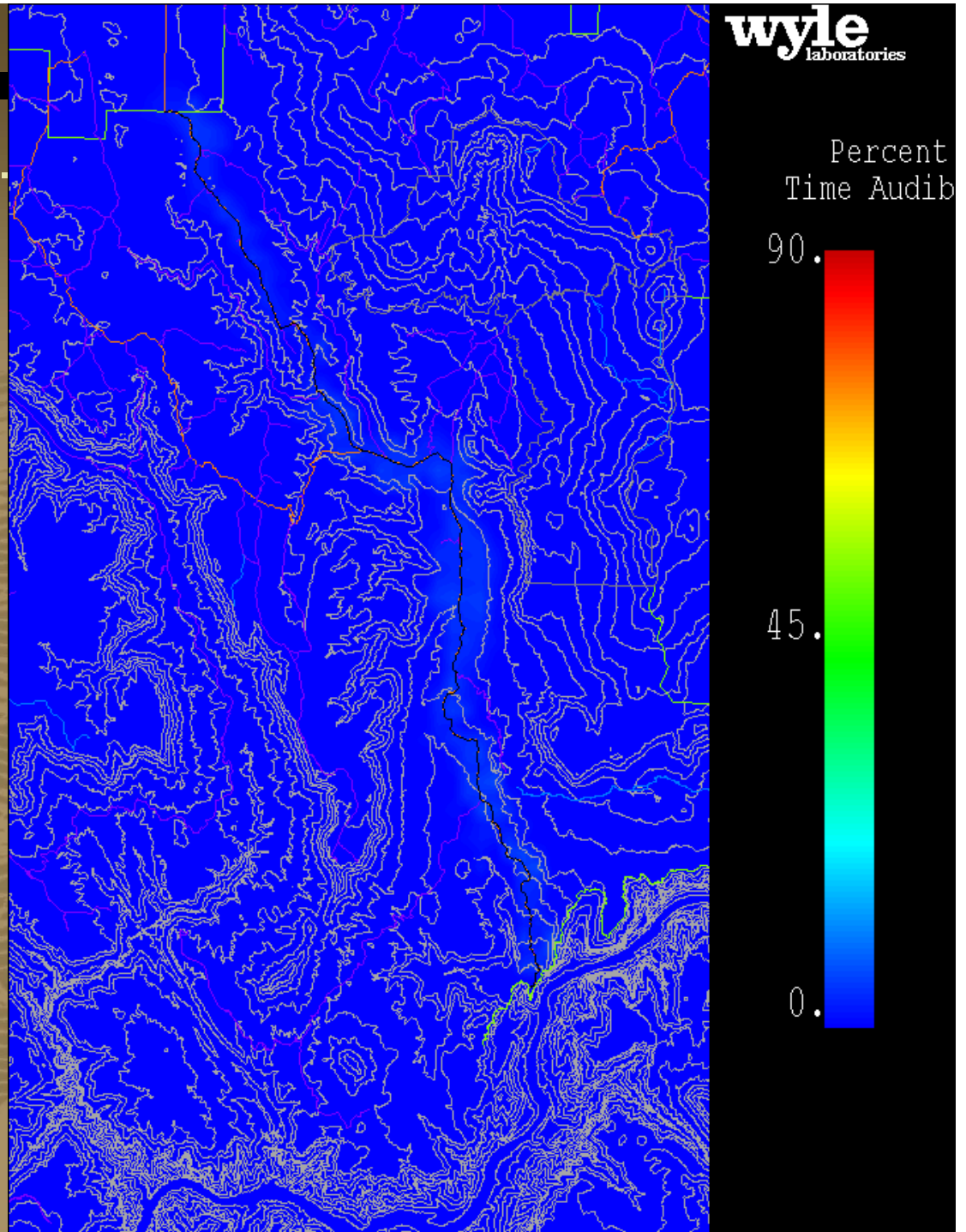
NPS Modeling-

- Morristown NHP strongly impacted by adjacent highway
- 65 dBA levels exceed speech interference thresholds
- Noise barriers or earth berms could be helpful, if feasible



NPS Modeling

- ORV noise in Grand Canyon – Parashant National Monument
- No open areas, but 121 miles of routes
- ORVs can be substantially louder than autos



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